PROJECT SUMMARIES

CHAIR OF APPLIED SYSTEMS ANALYSIS
CDR Matthew G. Boensel, USN
Department of Operations Research
Sponsor: Chief of Naval Operations–Assessment Division (N81)

OBJECTIVE: In accordance with the current Memorandum of Understanding between the Superintendent, Naval Postgraduate School and N81 (dated 12 April 1993), funds will provide research support for analysis of issues of interest to the Navy. Research will provide professional development of NPS faculty and students.

SUMMARY: Specific elements of this project include:
- Support for student thesis tours, in association with the OA program office.
- Support for faculty development in applied systems analysis and faculty travel to DC in support of N81 activities.
- Support for student and faculty travel for thesis research projects.

Of note, a special short course refresher on Operations Research methods was developed and delivered for action officers in the Assessment Division (N81).

PRESENTATIONS:

Washburn, A., "Introduction to Military Operations Research," Pentagon, Arlington, VA, 21-25 May 2001.

THESIS DIRECTED:

Borden, K., "Optimizing the Number and Employment of Combat Logistics Force Shuttle Ships, with a Case Study of the New T-AKE Ship," Masters Thesis, Naval Postgraduate School, September 2001.

DoD KEY TECHNOLOGY AREA: Other (Operations Research)

KEYWORDS: Optimization, Operations Research, Combat Logistics

AN ARCHITECTURE FOR DYNAMIC PLANNING SYSTEMS
USING LOOSELY COUPLED COMPONENTS
Gordon H. Bradley, Professor
Arnold H. Buss, Assistant Professor
Department of Operations Research
Sponsor: Air Force Office of Scientific Research

OBJECTIVE: Design and develop an architecture for dynamic map-based military planning applications using new platform-independent software technology. This is a continuing research project.

SUMMARY: The research has designed and developed a "loosely coupled components" architecture that has been demonstrated by constructing a map-based planning system for dynamic military planning. The architecture coordinates a collection of components that operate over heterogeneous computer networks. The system accesses and displays data, maps, overlays, algorithms, and other information. The components perform tasks such as: displaying maps, satellite images, and overlays; accessing, entering, and modifying data; constructing and displaying models of military operations; and accessing and executing algorithms to analyze operations. The design allows systems to be easily extended by adding addition components.

PRESENTATIONS:

Bradley, G. and Buss, A., "Loosely Coupled Components for Near Real Time Modeling and Optimization," Air Force Office of Scientific Research PI Meeting, Minnowbrook, NY, 11-13 November 2001.

Bradley, G. and Buss, A., "Demonstration System for a Military Mission," Air Force Office of Scientific Research PI Meeting, Minnowbrook, NY, 11-13 November 2001.

Bradley, G., "M&S in Classroom Instruction and Thesis Research at the Naval Postgraduate School," NAVMSMO Technical Interchange Meeting, National Defense University, Ft. McNair, Washington, DC, 23 August 2001.

THESES DIRECTED:

Fricke, C., "Operational Logistics Wargame," Masters Thesis, Naval Postgraduate School, December 2001.

San Jose, A., "Analysis, Design, Implementation and Evaluation of Graphical Design Tool to Develop Discrete Event Simulation Models Using Event Graphs and Simkit," Masters Thesis, Naval Postgraduate School, September 2001.

Lenhardt, T., "Evaluation of Combat Service Support Logistics Concepts for Supplying a USMC Regimental Task Force," Masters Thesis, Naval Postgraduate School, September 2001.

OTHER:

Project Monterey: A system to support real-time and near real-time military decision-making using network models based on the Loosely Coupled Components Architecture (LCCA).

DoD KEY TECHNOLOGY AREAS: Command, Control and Communications, Computing and Software, Modeling and Simulation, Other (Decision Support Systems)

KEYWORDS: Dynamic Planning, Loosely Coupled Components, Platform Independent Software, Java

LARGE-SCALE OPTIMIZATION
Gordon H. Bradley, Professor
Gerald G. Brown, Distinguished Professor
R. Kevin Wood, Professor
Department of Operations Research
Sponsor: Office of Naval Research

OBJECTIVE: Use large-scale mathematical programming techniques to solve deterministic and stochastic extensions of important combinatorial optimization models, and develop graph and network algorithms for dynamic map-based military planning. This is a continuing research project.

SUMMARY: One part of this research developed a new algorithm called BEST (Bound, Enumerate, Sample and Test) for solving two-stage stochastic integer programs. The algorithm has been applied to network-interdiction problems with uncertain interdiction success. Another part of this research designed and developed a toolkit of methods to quickly construct graph and network algorithms. The algorithms were integrated into a dynamic map-based military planning system that operates over heterogeneous computer networks. The system can download algorithms over a computer network and execute them to analyze operations. The design allows algorithms to be easily added to the planning system.

PUBLICATIONS:

Brown, G., Keegan, J., Vigus, B. and Wood, K., "The Kellogg Company Optimizes Production, Inventory and Distribution," *Interfaces*, Vol. 31, pp. 1-15, 2001.

Israeli, E. and Wood, K., "Shortest-Path Network Interdiction," in review.

PROJECT SUMMARIES

PRESENTATIONS:

Bradley, G. and Buss, A., "Loosely Coupled Components for Near Real Time Modeling and Optimization," Air Force Office of Scientific Research PI Meeting, Minnowbrook, NY, 11-13 November 2001.

Bradley, G. and Buss, A., "Demonstration System for a Military Mission," Air Force Office of Scientific Research PI Meeting, Minnowbrook, NY, 11-13 November 2001.

Bradley, G., "M&S in Classroom Instruction and Thesis Research at the Naval Postgraduate School," NAVMSMO Technical Interchange Meeting, National Defense University, Ft. McNair, Washington, DC, 23 August 2001.

Brown, G., "Fast Theater Attack Model," Air Force Office of Scientific Research PI Meeting, Minnowbrook, NY, 11-13 November 2001.

Brown, G., Byrne, P. and Washburn, A., "Fast Theater Model (FATHM)," 69th Military Operations Research Society Symposium, U. S. Naval Academy, Annapolis, MD, 12-14 June 2001.

Brown, G.G. and Dell, R.F., "Tutorial on Optimizing Military Capital Budgeting," 69th Military Operations Research Society Symposium, U.S. Naval Academy, Annapolis, MD, 12-14 June 2001.

Brown, G.G. and Newman, A., "Optimizing Tomahawk Strikes," 69th Military Operations Research Society Symposium, U.S. Naval Academy, Annapolis, MD, 12-14 June 2001.

Morton, D., Salmeron, J. and Wood, K., "A Sampling-Based Cutting-Plane Method for Stochastic Programs," INFORMS National Meeting, Miami Beach, FL, 4-7 November 2001.

Morton, D., Salmeron, J. and Wood, R.K., "A Stochastic Program for Optimizing Military Sealift Subject to Attack," Workshop on Decision-Making Under Uncertainty, Molde, Norway, 18-20 May 2001.

Sanchez, S. and Wood, K., "Solving Stochastic Network Interdiction Problems with the Partially Enumerate Then Screen Method," INFORMS International Hawaii, Maui, HI, 17-20 June 2001.

Sanchez, S. and Wood, K., "Stochastic Network Interdiction," Air Force Office of Scientific Research PI Meeting, Minnowbrook, NY, 11-13 November 2001.

Sanchez, S. and Wood, K., "Stochastic Network Interdiction," Mathematics Department Seminar, University of California at Davis, Davis, CA, 5 October 2001.

Wood, K., "Network Interdiction," Sandia National Laboratories, Albuquerque, NM, 2 July 2001.

THESES DIRECTED:

Bingol, L., "A Lagrangian Heuristic for Solving a Network Interdiction Problem," Masters Thesis, Naval Postgraduate School, December 2001.

Borden, K.D., "Optimizing the Number and Employment of Combat Logistics Force Shuttle Ships, with a Case Study of the New T-AKE Ship," Masters Thesis, Naval Postgraduate School, September 2001.

Garcia, R.M., "Optimized Procurement and Retirement Planning of Navy Ships and Aircraft," Masters Thesis, Naval Postgraduate School, December 2001.

Kubu, J.A., "Enhancing Real-time Tomahawk Predesignation to Diagnose Conflicts, Prescribe Improvements, and Plan Multiple Strikes," Masters Thesis, Naval Postgraduate School, September 2001.

Wingeart, P.H., "An Improved Heuristic for Tomahawk Land-Attack Predesignation, Enhanced to Accommodate Manual Planning and Validated with Fleet Exercise Data," Masters Thesis, Naval Postgraduate School, September 2001.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Modeling and Simulation, Other (Decision Support Systems)

KEYWORDS: Integer Programming, Stochastic Programming, Dynamic Planning

FAST THEATER MODEL
Gerald G. Brown, Distinguished Professor
Alan Washburn, Professor
Department of Operations Research
Sponsors: Joint Staff (J8) and the Naval Postgraduate School

OBJECTIVE: Provide support to the Joint Chiefs of Staff in improving FATHM, the FAst THeater Model.

SUMMARY: FATHM is an aggregated combat model that is part optimization and part simulation, a hybrid model. Air-to-ground activity is optimized, while ground-to-ground activity is simulated using a Lanchester model that imitates COSAGE, a high-resolution simulation. Progress in FY2001 includes
- a mechanism for target valuation
- based on target valuation, a mechanism for calculating force ratios and FEBA movement
- direct calls to an LP solver, a more efficient method than indirect calls via GAMS
- an improved method for calculating Lanchester coefficients based on the COSAGE killer-victim scoreboard
- improved input and output procedures

PUBLICATIONS:

Washburn, A., *The Fast Theater Model (FATHM)*, Naval Postgraduate School Technical Report, NPS-OR-01-002-PR, 2001.

PRESENTATIONS:

Brown, G., Byrne, P. and Washburn, A., "The Fast Theater Model," 69th Military Operations Research Society Symposium, 12-14 June 2001.

DoD KEY TECHNOLOGY AREA: Modeling and Simulation

KEYWORDS: Optimization, Weapon Allocation

LARGE-SCALE OPTIMIZATION
Gerald G. Brown, Distinguished Professor
R. Kevin Wood, Professor
Department of Operations Research
Sponsor: Air Force Office of Scientific Research

OBJECTIVE: Use large-scale mathematical programming techniques to solve deterministic and stochastic extensions of important combinatorial optimization models and mathematical programs. Develop extensions of network-interdiction techniques to solve more general system interdiction models.

SUMMARY: Have completed and delivered to JCS/J8 and U.S. Army Center for Army Analysis, Ft. Belvoir, Virginia, the Fast Theater Model (FATHM), an integrated air-to-ground attack model (using large-

scale optimization) and ground-to-ground model (using Lanchester equations). FATHM runs full-scale theater wars in less than five minutes with all the fidelity expected by Air Force and Army planners. The goal is to distribute targets among our forces optimally, and also to gauge the weapons and platform requirements to win. In other research areas, a Lagrangian-relaxation technique has been developed for quickly solving certain network-interdiction problems, and have an extension of integer cutting planes for solving integer programs has been devised Unlike standard cuts, the "super-valid inequalities" can cut away valid integer solutions, but they are guaranteed to not cut away useful solutions.

PUBLICATIONS:

Brown, G., Keegan, J., Vigus, B. and Wood, K., "The Kellogg Company Optimizes Production, Inventory and Distribution," *Interfaces*, Vol. 31, pp. 1-15, 2001.

Israeli, E. and Wood, K., "Shortest-Path Network Interdiction," in review.

PRESENTATIONS:

Brown, G.G., "Fast Theater Attack Model," Air Force Office of Scientific Research PI Meeting, Minnowbrook, NY, 11-13 November 2001.

Brown, G.G., Byrne, P. and Washburn, A., "Fast Theater Model (FATHM)," 69th Military Operations Research Society Symposium, U. S. Naval Academy, Annapolis, MD, 12-14 June 2001.

Brown, G.G. and Dell, R.F., "Tutorial on Optimizing Military Capital Budgeting," 69th Military Operations Research Society Symposium, U.S. Naval Academy, Annapolis, MD, 12-14 June 2001.

Brown, G.G. and Newman, A., "Optimizing Tomahawk Strikes," 69th Military Operations Research Society Symposium, U.S. Naval Academy, Annapolis, MD, 12-14 June 2001.

Morton, D., Salmeron, J. and Wood, K., "A Sampling-Based Cutting-Plane Method for Stochastic Programs," INFORMS National Meeting, Miami Beach, FL, 4-7 November 2001.

Morton, D., Salmeron, J. and Wood, R.K., "A Stochastic Program for Optimizing Military Sealift Subject to Attack," Workshop on Decision-Making Under Uncertainty, Molde, Norway, 18-20 May 2001.

Sanchez, S. and Wood, K., "Solving Stochastic Network Interdiction Problems with the Partially Enumerate Then Screen Method," INFORMS International Hawaii, Maui, HI, 17-20 June 2001.

Sanchez, S. and Wood, K., "Stochastic Network Interdiction," Air Force Office of Scientific Research PI Meeting, Minnowbrook, NY, 11-13 November 2001.

Sanchez, S. and Wood, K., "Stochastic Network Interdiction," Mathematics Department Seminar, University of California at Davis, Davis, CA, 5 October 2001.

Wood, K., "Network Interdiction," Sandia National Laboratories, Albuquerque, NM, 2 July 2001.

THESES DIRECTED:

Bingol, L., "A Lagrangian Heuristic for Solving a Network Interdiction Problem," Masters Thesis, Naval Postgraduate School, December 2001.

Borden, K.D., "Optimizing the Number and Employment of Combat Logistics Force Shuttle Ships, with a Case Study of the New T-AKE Ship," Masters Thesis, Naval Postgraduate School, September 2001.

Garcia, R.M., "Optimized Procurement and Retirement Planning of Navy Ships and Aircraft," Masters Thesis, Naval Postgraduate School, December 2001.

Kubu, J.A., "Enhancing Real-time Tomahawk Predesignation to Diagnose Conflicts, Prescribe Improvements, and Plan Multiple Strikes," Masters Thesis, Naval Postgraduate School, September 2001.

Wingeart, P.H., "An Improved Heuristic for Tomahawk Land-Attack Predesignation, Enhanced to Accommodate Manual Planning, and Validated with Fleet Exercise Data," Masters Thesis, Naval Postgraduate School, September 2001.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation, Computing and Software, Other (Optimization, Decision Support Systems)

KEYWORDS: Integer Programming, Stochastic Programming, Network Interdiction

OPTIMIZING NAVY PROGRAM PLANNING
Gerald G. Brown, Distinguished Professor
Robert F. Dell, Associate Professor
Anton Rowe, Research Associate
Javier Salmeron, Research Assistant Professor
Department of Operations Research
Sponsor: Chief of Naval Operations (N81)

OBJECTIVE: To provide N81 with a desktop, optimization-based decision-support tool to integrate, rationalize, and schedule the way in which and the rate at which Navy capital spending programs should be conducted over the next 25 years.

SUMMARY: A prototype custom-built optimization-based decision-support system was delivered complete with graphical user interface and custom heuristic. The decision-support system prescribes complete scenarios that can follow all Navy guidelines, including details such as keeping shipyards efficiently employed, constraining aircraft average age, and meeting IWARS (Integrated Warfare Architecture) requirements. Without the system, complete scenarios must be manually assembled, which is a laborious, error-prone task. Efforts continue to improve the system.

PRESENTATIONS:

Dell, R.F. and Brown, G.G., "Tutorial on Optimizing Military Capital Budgeting," 69th Military Operations Research Society Symposium, U.S. Naval Academy, Annapolis, MD, 12-14 June 2001.

THESIS DIRECTED:

Garcia, R.M., "Optimized Procurement and Retirement Planning of Navy Ships and Aircraft," Masters Thesis, Naval Postgraduate School, December 2001.

OTHER:

Software: The following versions of the decision support system were delivered to N81.

Version	Delivered	Comments	Documentation
P.01.01	02/28/01	Prototype Interface. Heuristic Solver	No
P.03.03	06/04/01	Prototype Interface. Heuristic Solver	No
P.07.04	11/13/01	Prototype/semi-operative Interface. Heuristic Solver	Yes

DoD KEY TECHNOLOGY AREAS: Computing and Software, Modeling and Simulation, Other (Optimization and Decision Support)

KEYWORDS: Optimization, Large-Scale Optimization, Program Planning, Budgeting, Capital Budgeting

OPTIMIZING TOMAHAWK LAND ATTACK PREDESIGNATION

Gerald G. Brown, Distinguished Professor
Department of Operations Research
Alexandra M. Newman, Assistant Professor
Colorado School of Mines
Richard E. Rosenthal, Professor
Department of Operations Research
Sponsors: Naval Surface Warfare Center - Dahlgren Division
and Office of Naval Research

OBJECTIVE: Testing and refining a heuristic procedure to efficiently assign tasks requiring Tomahawk Land-Attack Missiles (TLAMs) to the firing platforms of a battle group, i.e., surface ships and submarines.

SUMMARY: A fast heuristic was developed to assign Tomahawk missiles to firing platforms. Solutions obtained with this heuristic were compared against those obtained manually by the Tomahawk Strike Coordinator, i.e., using current practice. The heuristic solutions are of better quality than the manual ones and can be obtained much more quickly than with any manual process. Additionally, the heuristic was enhanced to incorporate these operational features: (i) The ability to plan subsequent tasking before the execution of the current tasking; (ii) the ability to manually allocate tasks to firing platforms with the guidance of the heuristic; and (iii) a function for identifying why certain tasks might not be able to be assigned to firing platforms, and for suggesting task-list modifications that would make it possible to accommodate those tasks.

PUBLICATIONS:

Brown, G.G., Newman, A.M, Rosenthal, R.E. and Rowe, A.A., *Optimizing Tomahawk Strikes*, Naval Postgraduate School Technical Report, NPS-OR-01-001-PR, January 2001, (also appeared in *Naval Postgraduate School Research Newsletter*).

PRESENTATIONS:

Brown, G.G., Newman, A.M., Rosenthal, R.E. and Rowe, A.A., "Optimizing Tomahawk Strikes," 69th Military Operations Research Society Symposium, U.S. Naval Academy, Annapolis, MD, 12-14 June 2001.

THESES:

Kubu, J.A., "Enhancing Real-time Tomahawk Predesignation to Diagnose Conflicts, Prescribe Improvements, and Plan Multiple Strikes," Masters Thesis, Naval Postgraduate School, September 2001.

Wingeart, P.H., "An Improved Heuristic for Tomahawk Land-Attack Predesignation, Enhanced to Accommodate Manual Planning, and Validated with Fleet Exercise Data," Masters Thesis, Naval Postgraduate School, September 2001.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation, Surface/Under Surface Vehicles, Ships and Watercraft

KEYWORDS: Missiles, Missile Selection, Naval Operations, Tomahawk Land Attack Missile

PROJECT SUMMARIES

MARITIME OPERATIONS SIMULATION AND APPLICABILITY ASSESSMENT FOR DEEPWATER
Arnie Buss, Assistant Professor
Department of Operations Research
Sponsor: United States Coast Guard

OBJECTIVE: Determine if contractor-supplied software tools will meet the Coast Guard's needs for modeling deepwater acquisition.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation

KEYWORDS: Deepwater Acquisition, Simulation, Validation

ANALYSIS IN SUPPORT OF USMC PME SURVEY
Samuel E. Buttrey, Assistant Professor
Lyn R. Whitaker, Associate Professor
Department of Operations Research
Sponsor: Marine Corps Combat Development Command

OBJECTIVE: To provide support to the Studies and Analysis Division (S&A), Marine Corps Combat Development Command for completion of the Marine Corps Professional Military Education (PME) Study. Specifically, to provide assistance with survey question development, survey data analysis, and to be the principal performers of data mining and analysis of existing Marine Corps databases in order to complete Tasks 2-4 in the PME Study Directive.

SUMMARY: This research project was a short fuse project with very specific deliverables. The primary purpose of NPS involvement was to provide S&A with any statistical support needed in their study of PME for the Marine Corps University. All deadlines and deliverables were met. These included help with constructing and on-line survey administered to all USMC officers. This survey captured views of officers about their PME experiences and their views of the importance and impact on USMC of resident and nonresident PME. Extensive summary statistics, corresponding graphics and interpretation of the results of this survey were delivered to S&A. These were incorporated into the final report. In addition, the Center for Naval Analysis data base, the USMC officer "Street to Fleet" data was scrutinized to see if there was any relationship between PME history and success as measured by promotion to various ranks and length of retention. The results of this analysis, including descriptive statistics and model fits to account for other variables influencing success, were delivered to S&A in the form of an interim report. These results were also used in the final report. Because the primary role of NPS was support for S&A's study, the results of NPS's contributions are integrated into S&A's report: "Professional Military Education Study for Marine Corps University: Final Report" (2001).

DoD KEY TECHNOLOGY AREAS: Manpower, Personnel and Training

KEYWORDS: Professional Military Education (PME), Manpower, Education

ANALYSIS OF PRE SOURCE INFORMATION
Samuel E. Buttrey, Assistant Professor
Department of Operations Research
Sponsor: Personnel Security Research Center

OBJECTIVE: To provide support to PERSEREC in analyzing the quality of information provided to their investigators by different sources with regard to different security considerations.

SUMMARY: This research project supported PERSEREC in measuring the quality of the information provided by different sources in their investigation of personnel receiving security clearances. Particular

attention was paid to the problem of inter-rater reliability (gauging the extent to which different investigators reach the same conclusions when presented with the same report), or IRR. The results of this analysis, including descriptive statistics, test of hypothesis, and measures of IRR were delivered to PERSEREC for inclusion in that organization's final report.

DoD KEY TECHNOLOGY AREAS: Manpower, Personnel and Training

KEYWORDS: Manpower, Security Clearance, Inter-rater Reliability

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OPTIMIZATION MODELS FOR INSTALLATION MANAGEMENT
Robert F. Dell, Associate Professor
Department of Operations Research
Sponsor: U.S. Army, Assistant Chief of Staff for Installation Management

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OBJECTIVE: Develop optimization models to assist with installation management.

SUMMARY: The investigator is providing research, support, and development of optimization models to assist the Army's Assistant Chief of Staff for Installation Management. The integer-linear programs OSAF (Optimal Stationing of Army Forces) and BAEC (Budget Allocation for Environmental Cleanup) were the primary 2001 development effort. The Center for Army Analysis used OSAF for numerous stationing studies and to help answer a QDR (Quadrennial Defense Review) issue: "What are the infrastructure requirements to support the Army of the future?" The Army's Base Realignment and Closure Office used BAEC to help plan $414 million in environmental cleanup at 334 sites on 54 current and former Army installations.

PUBLICATIONS:

Connor, G., Dell, R.F. and Tarantino, W.J., "An Integer Linear Program to Recommend Stationing of Army Forces," 27 November 2001. (Draft paper selected as a Finalist for 2001 Military Operations Research Richard H. Barchi Prize.)

PRESENTATIONS:

Tarantino, W.J, Dell, R.F. and Connor, G., "Optimal Stationing of Army Forces (OSAF)," 69th Military Operations Research Society Symposium, U.S. Naval Academy, Annapolis, MD, 12-14 June 2001.

Dell, R.F. and Tarantino, W.J., "Optimal Stationing of Army Forces," National Meeting of the Institute for Operations Research and the Management Sciences, Miami Beach, FL, 4-7 November 2001.

THESES DIRECTED:

Ardic, S., "Funding Site Cleanup at Closing Army Installations: A Stochastic Optimization Approach," Masters Thesis, Naval Postgraduate School, December 2001.

Gezer, M., "Optimal Stationing of the United States Army Forces in Korea," Masters Thesis, Naval Postgraduate School, December 2001.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation, Other (Optimization)

KEYWORDS: BRAC, Capital Budgeting, Optimization, Mixed Linear Integer Programming Application

PLANNING CAPITAL INVESTMENTS USING OPTIMIZATION
Robert F. Dell, Associate Professor
Department of Operations Research
Sponsor: Office of Naval Research

OBJECTIVE: Conduct research in optimal planning of capital investments with two short-term subjects, (a) the Capital Investment Planning Aide (CIPA) for U.S. Navy Force Structure planning and (b) the Japan Petroleum Distribution model (JPDM) for U.S. Navy infrastructure planning.

SUMMARY: This effort to conduct research on theory and algorithms for solving real-world capital budgeting problems with prescriptive optimization had two short-term goals. The first was to enhance the Capital Investment Planning Aide (CIPA) for U.S. Navy Force Structure planning. We have formulated an optimization model of the Navy's spending plans for major weapons systems (e.g., ships and aircraft) and demonstrated it with current planning data. The second short-term goal was to enhance the Japan Petroleum Distribution model (JPDM) for U.S. Navy infrastructure planning. Several new models were developed.

PRESENTATIONS:

Dell, R.F. and Brown, G.G, "Tutorial on Optimizing Military Capital Budgeting," 69th Military Operations Research Society Symposium, U.S. Naval Academy, Annapolis, MD, 12-14 June 2001.

Dell, R.F. and Noble, J.D., "Scheduling and Distributing Intra-Theatre Wartime POL Requirements," 69th Military Operations Research Society Symposium, U.S. Naval Academy, Annapolis, MD, 12-14 June 2001.

THESES DIRECTED:

Devlin, D.L., "Scheduling and Distributing Intra-Theater Wartime POL Requirements Under Uncertainty," Masters Thesis, Naval Postgraduate School, December 2001.

Garcia, R.M., "Optimized Procurement and Retirement Planning of Navy Ships and Aircraft," Masters Thesis, Naval Postgraduate School, December 2001.

Harmon, J.V., "Planning U.S. Pacific Command Wartime Fuel Distribution," Masters Thesis, Naval Postgraduate School, September 2001.

OTHER:

Software: The following versions of CIPA were delivered to N81.

Version	Delivered	Comments	Documentation
P.01.01	02/28/01	Prototype Interface. Heuristic Solver	No
P.03.03	06/04/01	Prototype Interface. Heuristic Solver	No
P.07.04	11/13/01	Prototype/semi-operative Interface. Heuristic Solver	Yes

DoD KEY TECHNOLOGY AREAS: Computing and Software, Modeling and Simulation, Other (Optimization and Decision Support)

KEYWORDS: Optimization, Large-Scale Optimization, Program Planning, Budgeting, Capital Budgeting, Other (Optimization and Decision Support)

PROJECT SUMMARIES

OPTIMIZING THE FLOW OF MARINE RECRUITS
THROUGH ENTRY-LEVEL TRAINING
Robert F. Dell, Associate Professor
Javier Salmeron, Research Assistant Professor
Department of Operations Research
Sponsor: U.S. Marine Corps Combat Development Command

OBJECTIVE: Assist the Marine Corps in developing an optimization model to prescribe a flow of enlisted recruits through entry-level training.

SUMMARY: The Marine Corps viewed the total time non-infantry enlisted wait for MOS training as unacceptably high. Integer linear programs were developed that model the flow of enlisted recruits through entry-level training. The models' recommendations highlight how more coordinated actions by recruiting planners and military occupational schools can significantly reduce the total Marine-year wait time. Tests carried out employing recent data show reductions of more than 50 percent.

THESIS DIRECTED:

Whaley, D.L., "Scheduling the Recruiting and MOS Training of Enlisted Marines," Masters Thesis, Naval Postgraduate School, December 2001.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Manpower, Personnel and Training, Modeling and Simulation, Other (Optimization)

KEYWORDS: Integer Optimization, Scheduling, Resource Constrained Problems

NAVY AIRLIFT
William Gates, Associate Professor
Graduate School of Business and Public Policy
Alan Washburn, Professor
Department of Operations Research
Sponsor: Chief of Naval Operations (N78)

OBJECTIVE: The Navy operates a fleet of operational support aircraft (OSA) that have the function of moving high priority passengers and cargo in wartime. The fleet is aging, and must gradually be replaced with more modern aircraft. The objective is first to measure the wartime demand for OSA transport in the event of a major war, and then to design a fleet that satisfies that demand at minimal cost.

SUMMARY: The basic approach is to estimate wartime demand for OSA transport, and then design a fleet that can meet that demand efficiently, bearing in mind that the costs of current OSA aircraft are "sunk." A fleet management tool OSAMIX is developed as an Excel workbook. Peacetime demand is estimated by recovering appropriate records from the JALIS database system, and then inflated to prospective wartime demand by applying a "surge factor." Given the characteristics of various aircraft, OSAMIX then finds the fleet that minimizes the present value of the costs of meeting that demand. One conclusion is that it is cost-effective for the Navy to retire its fleet of C-12 turboprop aircraft in favor of a similarly scaled jet aircraft.

PUBLICATIONS:

Gates, W. and Washburn, A., *The Navy Operational Support Aircraft Fleet*, Naval Postgraduate School Technical Report, NPS-OR-01-006-PR, 2001.

THESIS DIRECTED:

Law, J., "Assessing the Performance and Cost of Logistics Airfleet Options," Masters Thesis, Naval Postgraduate School, December 2001.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation

KEYWORDS: OSA, Operational Support Aircraft, Cost-Effective

ANALYTICAL DECISION-SUPPORTING RESEARCH USING SYNTHESIZED ADAPTIVE-AGENT-BASED MODELING AND MATHEMATICAL MODELING
Donald P. Gaver, Distinguished Professor
Patricia A. Jacobs, Professor
Department of Operations Research
Sponsor: The Modeling, Virtual Environments and Simluation (MOVES) Institute

OBJECTIVE: Purpose of the research is to formulate and study models for the adaptive scheduling of time critical tasks under imperfect information in joint warfare with a view towards guiding allocation of acquisition and eventually operational resources. The emphasis is on modeling the impact of information obtained from realistically imperfect sensor systems on interactive and joint conflicts. The purpose of the modeling and analysis is to explore the advantages of using Genetic Algorithms in the adaptive scheduling of processing of time-critical tasks, with imperfectly known identity and arriving in random streams of "unknown," i.e., changing, properties. This is a generalization of the General Assignment Problem (GAP) treated (under assumptions of certainty) by mathematical programming. The models here are called the Generalized Generalized Assignment Problem (GGAP).

SUMMARY: Models for allocation of service to time-critical tasks with uncertain outcomes have been formulated.

PUBLICATIONS:

Glazebrook, K.D., Gaver, D.P. and Jacobs P.A., *On a Military Scheduling Problem*, Naval Postgraduate School Technical Report, NPS-OR-01-010, August 2001.

PRESENTATIONS:

Gaver, D.P., Glazebrook, K.D., Jacobs, P.A. and Takahara, G., "On Service of Time-Limited Tasks with Uncertain Outcomes (Uncertain Time-Critical Tasking)," XXI International Seminar on Stability Problems for Stochastic Models, Eger, Hungary, 28 January-3 February 2001.

Gaver, D.P., Jacobs, P.A. and Takahara, G., "On Service of Time-Limited Tasks with Uncertain Outcomes (Uncertain Time-Critical Tasking)," INFORMS International Hawaii, Maui, HI, 17-20 June 2001.

Gaver, D.P., Jacobs, P.A. and Takahara, G., "On Service of Time-Limited Tasks with Uncertain Outcomes (Uncertain Time-Critical Tasking)," MIT Lincoln Laboratory, 16 July 2001.

Gaver, D.P., Jacobs, P.A. and Pilnick, S.E., "Hybrid Approaches to Agent-Based Complex Adaptive Systems," MOVES Open House, 30 August 2001.

Gaver, D.P., Jacobs, P.A. and Pilnick, S.E., "Some Thesis Research Topics in Stochastic/Probabilistic OR," Presentation to MV4900, 6 December 2001.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation

KEYWORDS: General Assignment Program, Generic Algorithms, Generalized Generalized Assignment Problem, GAP, GGAP

PROJECT SUMMARIES

JOINT EXPERIMENTATION HIGH-LEVEL LOW-RESOLUTION MODELING
Donald P. Gaver, Distinguished Professor
Patricia A. Jacobs, Professor
Department of Operations Research
Steven E. Pilnick, Senior Lecturer
Wayne E. Meyer Institute of Systems Engineering
Sponsor: U.S. Joint Forces Command and the Naval Postgraduate School

OBJECTIVE: Purpose of the research is to formulate and study state space models for information operations in joint warfare with a view towards guiding allocation of acquisition and eventually operational resources. The emphasis is on modeling the impact of information obtained from realistically imperfect sensor systems on interactive and joint conflicts

SUMMARY: High-level-low-resolution models for the study of the Common Relevant Operational Picture (CROP) have been formulated, studied and used to provide insight on the benefits of the CROP.

PUBLICATIONS:

Gaver, D.P. and Jacobs, P.A., "A Model for Analyzing Blue Force Response to Region Invasion by Multi-Type Red Forces," forthcoming.

Barkdoll, T.C., Gaver, D.P., Glazebrook, K.D., Jacobs, P.A. and Posadas, S., "Suppression of Enemy Air Defenses (SEAD) as an Information Duel," to appear in *Naval Research Logistics*.

DoD KEY TECHNOLOGY AREAS: Human-System Interface, Modeling and Simulation

KEYWORDS: Combat Models, Bayesian Perception Updating, Decision Analysis

MODELS FOR LIVER INSULT AND RECOVERY
Donald P. Gaver, Distinguished Professor
Patricia A. Jacobs, Professor
Department of Operations Research
Sponsor: Naval Health Research Center Detachment – Toxicology

OBJECTIVE: Use mathematical computer-based modeling and statistical methods to quantify the effects of a toxin on the liver.

SUMMARY: Mechanistic models for the effect of a toxic substance on the liver have been developed and experimental data have been analyzed.

CONFERENCE PRESENTATIONS:

Gaver, D.P., Jacobs, P.A., Carpenter, R.L., Robinson, P. and Bobb, A., "Towards a Model of Liver Insult and Recovery After Insult by Xenobiotic Chemicals," Poster Session, 40th Annual Meeting, Society of Toxicology, San Francisco, CA, 24–29 March 2001.

OTHER:

Carpenter, R.L., Gaver, D.P., Jacobs, P.A., Narayanan, T.K., Jung, A. and Bobb, A., "A Mechanistic Mathematical Models of Cell Toxicity from APAP," forthcoming.

Carpenter, R.L., Gaver, D.P., Jacobs, P.A., Robinson, P. and Bobb, A., "Towards a Model of Liver Insult and Recovery After Insult by Xenobiotic Chemicals," forthcoming.

Bobb, A., Carpenter, R.L., Gaver, D.P. and Jacobs, P.A., "High Dosage Model for the Effect of APAP on Liver Cells," forthcoming.

DoD KEY TECHNOLOGY AREAS: Biomedical, Human Systems Interface, Environmental Quality

KEYWORDS: PBPK/PD Compartment Modeling, Predictive Toxicology

TRAINING AND RESEARCH SUPPORT FOR DIRECTOR, OPERATIONAL TEST AND EVALUATION
Donald P. Gaver, Distinguished Professor
Patricia A. Jacobs, Professor
Department of Operations Research
Sponsors: Director, Operational Test and Evaluation, U.S. Army Analysis Command,
U.S. Army Training Analysis Command-Monterey and Naval Postgraduate School

OBJECTIVE: Purpose of the research is to develop training and reference material on a Web site and new methodology for operational testing which emphasizes modeling and simulation.

SUMMARY: Models for sequential stage system reliability growth via failure model removal have been formulated and studied. Models to assess the operational suitability of a platoon of advanced amphibious assault vehicles (AAAVs) have been formulated and studied. Materials for an operational test and evaluation Web site have been developed.

PUBLICATIONS:

Gaver, D.P., Jacobs, P.A. and Seglie, E., "Stochastic Models for Promoting and Testing System Reliability Evolution," *Safety & Reliability: ESREL 2001 Towards a Safer World,* Zio, E., Demichela, M., Piccinini, N., (eds.), Politecnico di Torino, Vol. 2, pp. 1109-1116, 2001.

Gaver, D.P, Jacobs, P.A. and Kemp, J., *Modeling the Operation of a Platoon of Amphibious Vehicles for Support of Operational Test and Evaluation (OT&E)*, Naval Postgraduate School Technical Report, NPS-OR-01-009, July 2001.

Gaver, D.P., Jacobs, P.A. and Seglie, E., *Stochastic Models for Promoting and Testing System Reliability Evolution*, Naval Postgraduate School Technical Report, NPS-OR-01-011, September 2001.

PRESENTATIONS:

Gaver, D.P., Jacobs, P.A and Seglie, E., "Stochastic Models for Promoting and Testing System Reliability Evolution," European Safety and Reliability Conference, Turino, Italy, 16-20 September 2001.

Gaver, D.P. and Jacobs, P.A., "Dynamic Reliability," Seminar at the Department of Statistics, University of California at Davis, 22 February 2001.

Gaver, D.P. and Jacobs, P.A., "Dynamic Reliability," Seminar at the Department of Statistics, Oregon State University, 26 February 2001.

Gaver, D.P. and Jacobs, P.A., "Dynamic Reliability," Seminar at the Department of Statistics, Birmingham University, 28 September 2001.

Gaver, D.P. and Jacobs, P.A., "Dynamic Reliability," Seminar at the Department of Statistics, University of Oslo, 5 October 2001.

PROJECT SUMMARIES

THESES DIRECTED:

Lintz, G., "Analysis of Reliability and Life Data for AN/ASS-44(V) Forward Looking Infrared System to Forecast H-60 Operational Availability," Masters Thesis, Naval Postgraduate School, September 2001.

Kemp. J., "Modeling and Simulation in Support of Operational Test and Evaluation for the Advanced Amphibious Assault Vehicle," Masters Thesis, Naval Postgraduate School, September 2001.

OTHER:

Bullock, G., "Delphi Software Implementation of Model for System Survival Probability," January 2001.

Bullock, G., "Delphi Software Implementation of Model for Sustainability of a Platoon of Amphibious Vehicles," June 2001.

Gaver, D.P., "Operational Test and Evaluation," Web Site: http://www.nps.navy.mil/opnsrsch/testeval/

DoD KEY TECHNOLOGY AREAS: Human-Systems Interface, Modeling and Simulation

KEYWORDS: Military Test and Evaluation, Statistical Data Analysis, Decision Analysis, Modeling and Simulation

DEVELOPMENT OF JOINT EXPERIMENTATION METHODOLOGY, HANDBOOK AND COURSEWARE
Thomas H. Hoivik, Senior Lecturer
Department of Operations Research
Sponsor: U.S. Joint Forces Command

OBJECTIVE: To develop a step-by-step joint experimentation planning and design methodology for U.S Joint Forces Command to use for planning and analysis of major Joint Experiments.

SUMMARY: Joint Experiments present a great opportunity for experimenting with new initiatives, which may include a variety of concepts, processes, or systems (CPS). However, there are mixed opinions about the value and validity of knowledge obtained during these past complex experiments. As a result, U.S. Joint Forces Command (J9) requested guidance on how to better plan, conduct and analyze complex joint experiments including the development of an experimentation handbook and courseware for training of participants. The research investigated and developed a detailed joint experimentation methodology including methods for identifying and fully defining concept, process or system issues and evaluation measures to gain insight into initiative effectiveness. The joint experimentation handbook and courseware introduced tools and techniques for better analysis, utilizing workshops, simulations and limited objective experiments, before large-scale wargames and complex joint and service experiments are conducted. The handbook will be used as a base reference and guide for future joint experimentation.

PUBLICATIONS:

Hoivik, T.H., "Fundamental of Joint Experimentation Planning and Design," U.S. Joint Forces Command (J9) Report, February 2002.

DoD KEY TECHNOLOGY AREAS: Battlespace Environments

KEYWORDS: Joint Experimentation, Joint Forces Command, Joint Warfare

PROJECT SUMMARIES

JOINT INTEROPERABILITY TESTING OF THEATER MISSILE DEFENSE SYSTEMS: LAUNCH POINT ESTIMATION AND IMPACT POINT PREDICTION

Robert A. Koyak, Assistant Professor
Department of Operations Research
Robert G. Hutchins, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Defense Information Systems Agency, Joint Interoperability Test Command

OBJECTIVE: To characterize in physical and statistical terms the launch points and impact points of ballistic missiles detected during flight, and to use these results to develop criteria for joint interoperability testing of sensor platforms engaged in joint air and space surveillance.

SUMMARY: The investigation considered how tracking information that is communicated between sensor platforms during joint air and space surveillance exercises can be used to test the validity of reported missile launch points and impact points. The extent of this information is limited due to bandwidth constraints. Inaccurate estimates of launch and impact points, and inconsistent methodologies between sensor platforms, result in a disruptive common air picture that impairs interoperability. Much of the uncertainty in these quantities derives from unknown characteristics of the missile (e.g., the ballistic coefficient) that are difficult to estimate under practical tracking conditions. Using simulation and statistical theory, the investigation succeeded in developing criteria that can be used for interoperability testing purposes. Research on this project has continued into CY 2002.

PUBLICATIONS:

Herrin, R.R., Barrett, N.L., Baker, B.G. and Koyak, R.A., "Joint Theater Air and Missile Defense Interoperability Testing Capabilities and Challenges," *ITEA Journal of Test and Evaluation*, Vol. 22, pp. 31–40, June/July 2001.

Koyak, R.A. and Hutchins, G.R., "Joint Interoperability Testing of Theater Missile Defense Systems: Launch Point Estimation and Impact Point Prediction," Technical Report, submitted to the Joint Interoperability Test Command (draft).

THESIS DIRECTED:

Leffers, J.W., "Statistical Validation of Track Quality Numbers for Joint Interoperability Testing of Theater Air and Missile Defense Families of Systems," Masters Thesis, Naval Postgraduate School, June 2001.

DoD KEY TECHNOLOGY AREAS: Command, Control and Communications, Sensors

KEYWORDS: Missile, Sensor, Tracking, Surveillance

EXPLORING ANALYSIS OF COMBAT DATA

Thomas W. Lucas, Associate Professor
Department of Operations Research
Sponsor: Naval Postgraduate School

OBJECTIVE: Attempt to validate models and look for invariant trends in data sets on historical battles.

SUMMARY: This research explores the validation of Lanchester equations as models of the attrition process for the Battle of Kursk in World War II. The methodology and results of this study extend previous validation efforts undertaken since the development of the Ardennes Campaign Simulation Data Base (ACSDB) in 1989 and the Kursk Data Base (KDB) in 1996. The KDB is a computerized database developed by the Dupuy Institute and the Center for Army Analysis from military archives in Germany and Russia. The data are two-sided, time-phased (daily), highly detailed, and encompass 15 days of the campaign. Also, CAA's CDB90G data set, which contains about 140 attributes on nearly 660 land battles

is being used to see what factors, over time, are associated with victory. Using classification trees, it was found that objective variables, by thems elves, cannot explain the outcome of battles. Relative factors, such as leadership, have deep impacts on success. The classification models also reveal that the factors affecting battle outcomes have changed over time. A leadership advantage played an important role for hundreds of years. However, in the 20th century, air sorties, tanks, and intelligence showed a higher importance.

PUBLICATIONS:

Lucas, T. and Turkes, T., "Fitting Lanchester Equations to the Battle of Kursk," submitted to *Naval Research Logistics*, 2001.

THESIS DIRECTED:

Coban, M., "Predicting Battle Outcomes With Classification Trees," Masters Thesis, Naval Postgraduate School, December 2001.

Dinges, J., "Exploring the Validation of Lanchester Equations for the Battle of Kursk," Masters Thesis, Naval Postgraduate School, June 2001.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation

KEYWORDS: Modeling and Simulation, Combat Analysis

CNET: PHASE III
David H. Olwell, Senior Lecturer
Department of Operations Research
Sponsor: Chief of Naval Education and Training

OBJECTIVE: Modify the Web-based content for OS2100 and deliver to NAVSEA using a mixture of instructional means.

SUMMARY: OS2100 has been previously prepared for Web-based delivery. In fall quarter, an opportunity arose to test the Web materials and simultaneously deliver the OS2100 course to four NAVSEA sites, using a mixture of on-site, video-teleconference, and web delivery methods. The materials were modified and the course was delivered. Student input indicates on-site instruction is preferred, that a mixture of modalities (Web, video, and on-site) is acceptable, and the Web-only is the last preference. Students whose duties resulted in travel during class periods depended on the Web materials to stay current, and many would not have completed the class without those materials being available. Different students had different learning styles, which resulted in differential use rates for the various course components. The lessons learned will be prepared in 2002 and disseminated.

DoD KEY TECHNOLOGY AREAS: Manpower, Personnel and Training

KEYWORDS: Distributed Learning, Web-Based Learning, Distance Learning

PROJECT SUMMARIES

OPTIMIZATION MODELING IN SUPPORT OF
TANKER REQUIREMENTS STUDY FOR 2005 (TRS-05)
Richard E. Rosenthal, Professor
Laura M. Williams, Research Assistant Professor
Department of Operations Research
LtCol Steven F. Baker, Associate Professor, U.S. Air Force Academy
Sponsor: Office of Secretary of Defense, Program Analysis and Evaluation

OBJECTIVE: To determine the number tanker airframes and aircrews needed to support the air mobility function in the years 2005 and beyond.

SUMMARY: Evaluation of tanker usage as well as overall system performance in the Weapons of Mass Destruction case has been completed. This analysis included excursions designed to analyze the effects of limited tanker forces, use of C130 aircraft as intra-theater shuttles, effects of limited fuel and airfield capacities. The analysis of tanker support for fighter drags is in progress. Model modifications and data analysis to support the fighter drag analysis is complete. The results of the fighter drag analysis are currently being validated with the help of Air Mobility Command personnel.

PUBLICATIONS:

Baker, S., Morton, D., Rosenthal, R. and Williams, L., "Optimizing Military Airlift, 2000," to appear in *Operations Research*, 2002.

Baker, S.F., Rosenthal, R. and Williams, L., *Tanker Requirements Study 2005: The Impact of Weapons of Mass Destruction Attack On Airlift Throughput*, Technical Report, Naval Postgraduate School.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation

KEYWORDS: Air Mobility, Aerial Refueling, Tankers, Mobilization

ADAPTIVE EXPLORATION OF AGENT-BASED COMMAND AND CONTROL SIMULATIONS
Susan Sanchez, Professor
Thomas W. Lucas, Associate Professor
Department of Operations Research
Sponsor: U.S. Marine Corps Combat Development Command

OBJECTIVE: Develop a framework that facilitates high-dimensional explorations of Agent-Based Command and Control Simulations.

SUMMARY: Analysts use combat models to provide information to decision-makers who must make and justify decisions involving billions of dollars and impacting many lives. Insights from combat models should be based on an ensemble of outcomes. This research helps build the foundation for a multi-year effort to define, test, and implement a new set of high-dimensional search strategies algorithms for use in exploring agent-based simulations. The prototype approaches that were developed automatically look across a breadth of factors and adaptively focus sampling efforts on the "interesting" effects and interactions. The efficiency of the search strategies under a variety of scenarios is being examined with computational experiments. These experiments are being conducted on known surfaces, using a stochastic response surface generator, and existing distillations.

PUBLICATIONS:

Lucas, T., Sanchez, S., Brown, L. and Vinyard, W., "Better Designs for High-Dimensional Explorations of Distillations," to appear in *Maneuver Warfare Science 2002*, Marine Corps Combat Development Command, Defense Automated Printing Service, 2002.

Sanchez, S.M. and Lucas, T., "Agent-based Simulations: Simple Models, Complex Analyses," Invited paper to appear in *Proceedings of the 2002 Winter Simulation Conference*, Snowdon, J.L., Charnes, J., Chen, C-H and Yucesan, E. (eds.), Institute of Electrical and Electronic Engineers, Piscataway, NJ, 2002.

PRESENTATIONS:

Lucas, T.W. and Sanchez, S.M., "Adaptive High-Dimensional Explorations of Agent-based Command and Control Simulations,"11/01 – INFORMS, Miami, FL, November 2001.

Sanchez, S.M. and Lucas, T.W., "Exploring Agent-based Simulations: Simple Models, Complex Analyses," 11/01 – INFORMS, Miami, FL, November 2001.

Sanchez, S.M. and Lucas, T.W., "Adaptive Exploration of Project Albert Distillations," INFORMS International, Maui, HI, June 2001.

Lucas, T.W. and Sanchez, S.M., "Adaptive Exploration of Agent-Based Command and Control Simulations," INFORMS Military Applications Society 4th Annual International Meeting, Quantico, VA, May 2001.

THESIS DIRECTED:

Ho, K.J., "An Analysis of Distributed Combat Systems," Masters Thesis, Naval Postgraduate School, December 2001.

Vinyard, W.C., "Reducing Non-monotonicities in Combat Models," Masters Thesis, Naval Postgraduate School, September 2001.

OTHER:

Vinyard, B. and Lucas, T., "Exploring Combat Models for Non-monotonicities and Remedies," submitted to *PHALANX*.

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications, Modeling and Simulation

KEYWORDS: Modeling and Simulation, Design of Experiments, Agent-based Models, Command, Control and Communications

CNET: PHASE III
Susan Sanchez, Professor
Department of Operations Research
Sponsor: Chief of Naval Education and Training

OBJECTIVE: Adapt the interactive computer cases and games to be used in a web-based course on operations analysis. Specifically, the goals were to make the modules for this Web-based course more user friendly, and to change the contexts from generic routing and distribution problems to military applications. This is a continuation of CNET: OPERATIONS ANALYSIS.

SUMMARY: Three software modules were added to the course materials for OS3000: Introduction to Management Science for Information Systems and Operations (ISO). Instructions for student assignments were written, and related topics were integrated into questions for the course's weekly web discussion board. The first module is an agent-based simulation that introduces the students to some basic concepts in simulation and experimental design by allowing them to investigate the efficacy of different command and control structures on a peacekeeping operation. The second module introduces the students to inventory control, and the impact that various ordering policies, lead times, and demand distributions have on both

total costs and the fill-rate. The third module motivates the use of shortest-path and min-low/max-cut problems for network interdiction. The basic software tools, instructions, and assignments were put in place during Fall 2001. Graphics enhancements continued through Winter 2002.

DoD KEY TECHNOLOGY AREAS: Manpower, Personnel and Training

KEYWORDS: Distributed Learning, Web-Based Learning, Distance Learning

DISTRIBUTED LEARNING: OPERATIONS ANALYSIS
Susan Sanchez, Professor
Department of Operations Research
Sponsor: Chief of Naval Education and Training

OBJECTIVE: Develop a framework for a case-oriented management science course for the ISO curriculum. Web-based elements of the course should both (1) form the basis for a high-quality, relevant distributed learning course for non-resident ISO students, and (2) enhance the learning experience for resident ISO students.

SUMMARY: The structure for online course delivery was put in place for OS3000: Introduction to Management Science for Information Systems and Operations (ISO). The course was offered as a web-enhanced course to resident students at NPS during Spring 01. Interactive java applets and computer games were used to illustrate the quantitative modeling framework for a variety of topics, such as inventory management, resource allocation, routing, scheduling, network interdiction, and network reliability. Web-based courseware distributed software, slides, and other course content, while Web discussion boards provided a forum for instructor-learner and learner-learner interactions. The team-based course structure provided the students with hands-on experience in defining problems, developing appropriate quantitative models, defending their model choices, and effectively communicating the results. Military examples were used to motivate the material, and ties to examples and scenarios from previous ISO coursework were put in place. Student teams were also responsible for preparing briefings on recent ISO applications that used tools related to those covered in class. Course development continued in CNET Phase III.

DoD KEY TECHNOLOGY AREAS: Manpower, Personnel and Training

KEYWORDS: Distributed Learning, Web-Based Learning, Distance Learning

ECONOMIC BENEFIT OF NAVAL FORWARD PRESENCE
David A. Schrady, Distinguished Professor
Department of Operations Research
R.L. Looney, Professor
Douglas Porch, Professor
Department of National Security Affairs
Sponsor: Chief of Naval Operation (N81)

OBJECTIVES: To develop an integrated framework for assessing the consequences of globalization on the market forces associated with naval forward presence and crisis response. This task will draw heavily on the expanding literature on globalization, integrating it with our quantitative findings on economic benefits.

SUMMARY: This study develops an integrated framework for assessing the consequences of globalization on the market forces likely to be affected by naval forward presence and crisis response. The study demonstrates that it is possible to develop an operational definition for quantifying globalization. The study found a clear linkage between the highly globalized countries and the manner in which oil shocks affect their economies. Over time, highly globalized countries including the United States have become more vulnerable to oil price shocks. Because naval forward presence and crisis response tends to suppress

oil shocks and return prices to their equilibrium levels, the role of naval activities in economic stabilization has not only taken on increased importance in recent years but, with the likely continuation of global trends, should play an even greater positive economic role for the United States in the foreseeable future.

PUBLICATONS:

Looney, R.E., Schrady, D.A., et al., "Estimating Economic Benefits of Naval Forward Presence: A Brief Summary," *Proceedings of Conference on Globalization and Naval Forward Presence*, Ch. 3, Institute for National Security Studies, National Defense University, Washington, DC, 19 April 2001.

Looney, R E., Schrady, D.A. and Brown, R.L., "Estimating the Economic Benefits of Forward-Engaged Naval Forces," *Interfaces*, Vol. 31, No. 4, July-August 2001.

Looney, R.E., Schrady, D.A. and Porch, D., *Economic Impact of Naval Forward Presence: Benefits, Linkage and Future Prospects as Modified by Trends in Globalization*, Naval Postgraduate School Technical Report, NPS-NSOR-02-001, December 2001.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation

KEYWORDS: Naval Forward Presence, Economic Benefits, Econometrics, Globalization

MODELING AND SIMULATION ANALYSIS FOR EXPEDITIONARY LOGISTICS
David A. Schrady, Distinguished Professor
Department of Operations Research
Sponsor: Office of Naval Research

OBJECTIVES: The objective is to support Metron, Inc. and Lockheed Martin who, separately, hold contracts for modeling and simulation of expeditionary logistics in support of the Future Naval Capabilities program of the Office of Naval Research.

SUMMARY: The effort has consisted of support and analyses defining and documenting logistics command and control, modeling and simulation, database, planning, and user interface requirements responsive to the ONR Future Naval Capabilities Expeditionary Logistics vision. It has further involved determination of the logistics representation enhancements needed in the Naval Simulation System in order to meet these requirements. Monthly activity reports were provided to both contractors for inclusion in their monthly reports to ONR.

PRESENTATION:

Schrady, D.A., "Combat Logistics," Commander Naval Forces Korea, Commanders Conference, Port Hueneme, CA, 10 February 2001.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation

KEYWORDS: Sustainability, Sea-Based Logistics, Expeditionary Logistics, Expeditionary Maneuver Warfare

PROJECT SUMMARIES

**RESEARCH ON AGGREGATED COMBAT MODELS II – METHODOLOGY FOR THE
COMPARATIVE EVALUATION OF MODELS**
James G. Taylor, Professor
Department of Operations Research
Sponsor: United States Army – Dismounted Battlespace Battle Lab (DBBL)

OBJECTIVE: To improve quantitative methodology for assisting in the selection of aggregated-force combat models and submodels, particularly for the attrition process. Also, to improve attrition methodologies for such models.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation

KEYWORDS: Combat Models, Evaluation of Combat Models, Attrition Methodologies

SUPPORT OF JCATS LIMITED V&V
James G. Taylor, Professor
Department of Operations Research
Sponsor: United States Army – Dismounted Battlespace Battle Lab (DBBL)

OBJECTIVE: Assist in the conduct of a limited verification and validation (V&V) of the non-lethal capabilities of the joint conflict and tactical simulation (JCATS). Primary attention is to be given to the verification of JCATS algorithms, particularly those for simulating the capabilities of non-lethal weapons (NLW).

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation

KEYWORDS: Model Verification/Validation, Non-Lethal Effects, Simulation of Joint Warfare

**SUPPORT OF PA&E CAMPAIGN MODEL PROGRAM (PAEP) (UPGRADING GROUND-
COMBAT ATTRITION AND MOVEMENT AND IMPROVING TREATMENT OF
UNCERTAINTIES**
James G. Taylor, Professor
Department of Operations Research
Sponsor: Office of the Secretary of Defense

OBJECTIVE: Provide support for upgrading the PA&E campaign model program (PAEP) with the addition of a ground-force model (that is consistent with overall PAEP goals) and also for improving the treatment of uncertainties.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation

KEYWORDS: Weapons Scoring/Aggression, Ground-Combat Attrition, Ground-Force Movement

UPGRADING GROUND-COMBAT ATTRITION AND MOVEMENT FOR ITEM
James G. Taylor, Professor
Department of Operations Research
Sponsor: Defense Threat Reduction Agency

OBJECTIVE: Work closely with time developer (SAIC) to improve assessment algorithm for direct-fire ground-combat attrition in item. The new single-weapon-system-type kill rates recently developed by the proposed principal investigator would be basis with this upgrade.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation

KEYWORDS: Stand-Alone Attrition Methodol, Lanchester Attrition-Rate COEF, Direct-Fire Ground-Combat ATTR, Indirect-Fire Ground-Combat AT

LP/POMDP INFORMATION OPTIMIZATION METHODOLOGY
Alan Washburn, Professor
Department of Operations Research
Sponsor: Air Force Office of Scientific Research

OBJECTIVE: Develop and test an optimization method for jointly assigning sensor assets and firepower assets to a target set. The method will employ Linear Programming and Partially Observable Markiov Decision Processes to generate policies for joint, sequential assignments.

SUMMARY: Current theory is extended to include the effects of surveillance, as well as the effects of BDA (bomb damage assessment). A computer program JOIST has been produced that achieves solutions in minutes to hours for realistically scaled problems, depending on desired accuracy. The scenario considered by JOIST is one where sorties must be assigned to targets in an environment where information about the effects of strikes is expensive and imperfect, and where one effect of a sortie may be to discover new, previously unknown targets. Expected total target value killed is maximized while constraints on the availability of sorties and acceptable attrition are observed. The methodology is suitable for investigating the relative benefits of information and strike assets, and possibly for helping to construct air tasking orders. Efforts in the second year (2002) will be devoted to improving efficiency, and to transitioning JOIST to practical purposes.

PUBLICATIONS:

Washburn, A., *JOIST: Joint Optimizing Informational Strike Tool*, Naval Postgraduate School Project Report, NPS-OR-02-001-PR, 2001.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation

KEYWORDS: BDA, POMDP, Information

C130 TRAINING MODEL
Laura M. Williams, Research Assistant Professor
Department of Operations Research
Sponsor: 314th Airlift Wing, Little Rock Air Force Base

OBJECTIVE: The primary objective of this project is to provide a model, i.e., an automated tool, to create operational aircrew training schedules of varying time horizons for individual crewmembers in a variety of syllabi.

SUMMARY: The primary scheduling model, a set of mixed-integer programs designed to create good schedules in a reasonable amount of time, has been completed and is currently being thoroughly tested. Documentation and programming of a user interface are in progress. The user interface, joint work with the sponsor, is being designed to take advantage of the user's current data environment to make the model as easy as possible to use on a regular basis.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation

KEYWORDS: Scheduling, Training

PROJECT SUMMARIES

LARGE-SCALE MIXED INTEGER PROGRAMMING
R. Kevin Wood, Professor
Department of Operations Research
Sponsor: Joint Warfare Analysis Center

OBJECTIVE: Develop integer-programming methods, including decomposition, for solving interdiction problems under uncertainty.

SUMMARY: Available from sponsor.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Modeling and Simulation, Other (Optimization and Decision Support)

KEYWORDS: Optimization

SUPPORT FOR REAL-TIME EXECUTION DECISION SUPPORT (REDS)
R. Kevin Wood, Professor
Department of Operations Research
Sponsor: Office of Naval Research

OBJECTIVE: Provide technical support for the strike-planning and execution system (REDS, Real-time Execution Decision Support) being developed as the Space and Naval Warfare Systems Command, San Diego. Areas of interest include predicting locations of mobile targets, optimization of aircraft-to-target assignments and route planning.

SUMMARY: Potential techniques for predicting locations of mobile targets were explored. For purposes of familiarization, the PI visited Fallon Naval Air Station to observe how element-level strike planning is currently carried out; the execution of the planned strike was also observed.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Modeling and Simulation, Other (Optimization and Decision Support)

KEYWORDS: Optimization

SUPPORT FOR THE CENTER FOR OPERATIONS RESEARCH, NATIONAL SECURITY AGENCY
R. Kevin Wood, Professor
Department of Operations Research
Sponsor: National Security Agency

OBJECTIVE: Provide on-call analytical support to the National Security Agency.

SUMMARY: Available from sponsor.

THESES DIRECTED:

Bingol, L., "A Lagrangian Heuristic for Solving a Network Interdiction Problem," Masters Thesis, Naval Postgraduate School, December 2001.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Modeling and Simulation, Other (Optimization and Decision Support)

KEYWORDS: Optimization